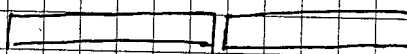


Fusion Splicing

1-5-2000

idea (1) Directly Splicing



change: Splicing time
Splicing currents

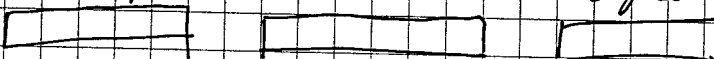
Arc Position: The higher the melting point, the closer the Arc.
Try to make the energy distribution asymmetric, higher at closer end, lower at far away end!!!

Idea position: The arc position is located in where that the temperature in both ends of fibers is nearly to melting points of the fiber. (at least the soften temperature)

idea (2) Immediate

Low temperature fiber

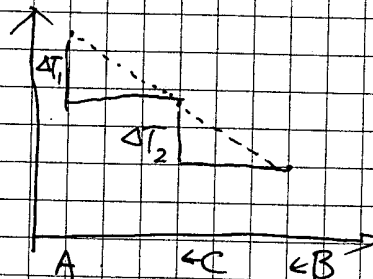
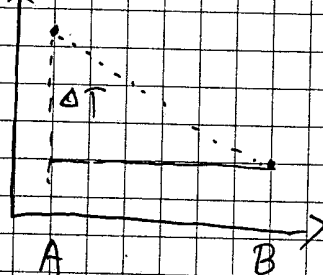
h. high temperature fiber



Immediate melting point fiber

two fiber system

Temp (°C) ↑

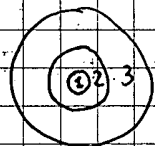


$$\Delta T_1 \sim \Delta T_2 \ll \Delta T$$

Order PFI (Thorlabs)

Ultra-high NA silica fibers
Coupler Fiber 3M

idea (3) double cladding layer



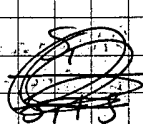
assume: $D_1 = 6.6 \mu m$
 $D_2 = 30 \mu m$
 $D_3 = 125 \mu m$

$$r_1 = 3.3 \mu m$$

$$r_2 = 15 \mu m$$

$$r_3 = 62.5 \mu m$$

$$\frac{S_1}{S_3} = \left(\frac{r_1}{r_3} \right)^2 = (0.0528)^2 = 0.00278$$



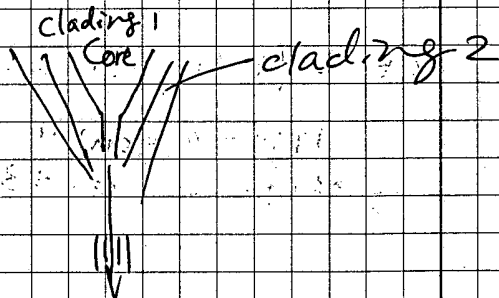
$\ll 1\%$

$$\frac{S_2}{S_3} = \left(\frac{r_2}{r_3} \right)^2 = (0.24)^2 = 5.76\%$$

if

$$\frac{S_2}{S_3} = 0.20 \quad \frac{r_2}{r_3} = 0.45$$

$$r_2 = 0.45 \times 125 = 56.25$$



procedure to produce the fiber needed to be developed

$$S_2/S_3 : 0.40 \quad 0.50 \quad 0.410$$

$$r_2 : 40 \text{ nm} \quad 50 \text{ nm} \quad 88 \text{ nm} \Rightarrow 0.80$$

Fusion Splice test on IF

Jan 9, 2001

SM + SM POI

Test time IF IF IF IF IF

Loss 0.02 dB IF -

Loss 0.03 dB IF F

Loss 0.04 dB T

Loss 0.01 dB IF 0

Loss 0.09 dB* -

Loss 0.05 dB IF

Loss 0.11 dB - **

Cleaved Bad F Dure to the Diamond
clever has not move all the way cross.

* Loss become 0.04 dB ~~when~~ after refuse

Cut & Refuse F

Failure F

** Left "recut and reuse"

right "new"

→ Refuse 0.33 dB

After electrode clean program run, The loss estim
is much lower, around 0.01 ~ 0.02 dB. Even one
sample that recut & re-splice.

Manual Mode Splicing

Jan 10, 2001

SM + SM PO1

Totate test time IF

lose 0.01 dB

lose 0.02 dB

lose 0.03 dB

lose 0.04 dB

lose 0.05 dB

lose 0.06 dB

lose 0.08 dB

P1 Change Parameters (Prefuse Curr)

	P01	P11	changed
Prefuse time	0.25	0.25	
Prefuse Curr	10.0 mA	0.80 mA	✓
Gap	50.0 μ m	50.0 μ m	
overlap	10.0 μ m	10.0 μ m	
fusion time 1	0.3 S	0.3 S	
fusion Curr 1	10.5 mA	10.5 mA	
time 2	2.0 S	2.0 S	
Curr 2	16.3 mA	16.3 mA	
time 3	2.0 S	2.0 S	
Curr 3	12.5 mA	12.5 mA	
left MFD	9.8 μ m	9.8 μ m	
Right MFD	9.8 μ m	9.8 μ m	
Set Center	+255	+255	
AOA Curr	0 mA	0 mA	
Early Prefus	No	No	
Align Accura	0.15 μ m	0.15 μ m	
loss shift	0 dB	0 dB	
Auto Arc Center	No	No	

Re-Edit

P12 Change Parameter (fusion Curr1)

	P12
prefuse	0.25
Prefuse curr	8.0 mA
Gap	50 μ m
overlap	10 μ m
fusion time 1	0.3 S
fusion curr 1	8. mA
time 2	2.0 S
Curr 2	16.3 S
time 3	2.0 S
Curr 3	16.3 S 12.5 S
Left MFD	9.8 μ m
Right MFD	9.8 μ m
S.Center	+255
AOA Curr	0 mA
Early Prefus	No

PO5 eccentric S + sm

Total test time IF -

lose	0.01 dB	T
lose	0.02 dB	T
lose	0.03 dB	
lose	0.04 dB	
lose	0.05 dB	T

P11 first programmed

total test time F

lose	0.01 dB	T
lose	0.08 dB	-*

P12 changed (fusion curr 1)

total test time IF -

lose	0.05 dB	T
lose	0.04 dB	T
lose	0.06 dB	-
lose	0.01 dB	-
* 0.04 dB	refuse	

P13

manual mode

{ Prefuse Curr 3.0 mA ✓

{ Prefuse time 0.3 s

Edit { Prefuse Curr 6. mA temp. too high
 { Prefuse time 0.3 s X Matchstick

~~OC~~

Edit { Prefuse Curr 4.5 mA X Matchstick
 { Prefuse time 0.3 s

~~OC~~

Edit { Prefuse Curr 3.75 mA (3.8 mA) X
 { Prefuse time 0.3 s Matchstick

~~OC~~

Edit { Prefuse Curr 3.4 mA ✓ No melting
 { Prefuse time 0.3 s

Edit { Prefuse Curr 3.6 mA just a little
 { Prefuse time 0.3 s too high

~~OC~~

1) fiber cannot be cut by cleaver.
 Mechanical property is poor

2) Prefuse Current 3.6 mA
 { Prefuse time 0.3 s

Current is very low

P14

Prefuse time	0.2 S
Prefuse Curr	3.4 mA
Gap	50 μ m
Overlap	10 μ A
fusion time 1	0.3 S
fusion Curren 1	3.85 mA
fusion time 2	2.0 S
fusion Curr 2	3.85 mA
fusion time 3	2.0 S
fusion Curr 3	3.4 mA
Left MFD	9.8 μ m
right MFD	9.8 μ m
Set Center	+2.55
AOA Curr	0 mA
Early prefuse	NO
Align Accura	0.15 μ m
loss shift	0 dB
Auto Arc Center	NO

too high for Erbium Glass, too low for SMF28
 The fiber of Erbium Glass is not uniform
 in ~~end~~ Diameter.

Fibercore glass

DF1500F-980 Erbium Doped Fibre
SD 278A-01A

"C-band" 1530-1560 nm

DF1500L Special Erbium-doped Fibre
SD 188B-00E

"L-Band",
Concentrate twice as high as DF-1500F
~ 1600 nm

DF1500L

DF1500F-0980

Fiber Diameter 125 μ m

NA 0.21

125 μ m

Cut-off 955 nm

0.24

Attenuation 25 dB/km 1200 nm

970 nm

Absorption 11.5 dB/m @ 979 nm

6.8 dB/km

14.6 dB/m @ 1531 nm

4.8 dB/m

6.6 dB/m

Composition Core Silica/germania

Inner cladding Silica

Same
asCoating Dual Coat UV Cure Acrylate
240 μ m Diameter

left

Mechanical

proof test @ 1% Strain

Program 01.

manual DF 1500 L & SMF-28 fusion splicing

0.09 dB	I
0.06 dB	—
0.02 dB	—

Auto mode	FE
0.07	—
0.01	T
0.02	T

SD 278 A - 01 A & SMF - 28

0.01 dB	—
0.03 dB	—
0.02 dB	—

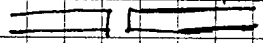
Program 15 a

Jan 16, 200

	15 a	15 b	15 c	15 d
Prefuse time	0.2 S	0.2 S	0.2 S	0.2 S
Prefuse Curr	3.3 mA	3.3 mA	3.0 mA	2.8 mA
GAP	50 μ m	50 μ m	50 μ m	50 μ m
Overlap	10 μ m	10 μ m	10 μ m	10 μ m
Fusion time 1	0.3 S	0.3 S	0.3 S	0.3 S
Fusion Curr	3.3 mA	3.3 mA	3.0 mA	2.8 mA
Fusion time 2	1.0 S	0.3 S	0.3 S	0.3 S
Fusion curr	3.3 mA	3.3 mA	3.0 mA	2.8 mA
Fusion time 3	1.0 S	0.3 S	0.3 S	0.3 S
Fusion Curr 3	3.3 mA	3.3 mA	3.0 mA	2.8 mA
left MFD	4.8 μ m	4.8 μ m	<	<
Right MFD	4.8 μ m	4.8 μ m	<	<
Set Center	+255	+255	<	<
AOA Current	0 mA	0 mA	<	<
Early Prefuse	No	No	<	<
Align Accura	0.15 μ m	0.15 μ m	<	<
loss shift	0 dB	0 dB	<	<
Auto Arc Center	no	NO	<	<

< Same as left

Result

(1) Can not fusion Splice two standard SMF-28 Fiber  Same as 15a Not good Cannot stick together

(2) Prefusion cannot clean up SMF-28 Fiber but do melt the phosphate fiber a little. Same as 15a Not good Since phosphate doesn't melt

fusion stage make to phosphate fiber melting and becoming a match-stick.



15 d	15 e	15 f	15 g	15 A
0.2 S	0.2 S	0.2 S	0.1 S	0.1 S
2.8 mA	2.9 mA	2.9 mA	3.3 mA	3.2 mA
	50 μ m	50 μ m	50 μ m	50 μ m
	10 μ m	10 μ m	10 μ m	10 μ m
0.3 S	0.3 S	0.6 S	0.1 S	0.1 S
2.8 mA	3.0 mA	2.9 mA	3.3 mA	3.2 mA
1.3 S	0.3 S	1.3 S	1.3 S	1.3 S
2.8 mA	2.9 mA	2.9 mA	2.8 mA	2.8 mA
1.3 S	1.3 S	1.3 S	1.3 S	1.3 S
2.8 mA	2.9 mA	2.9 mA	2.8 mA	2.8 mA
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		
←	←	←		

NP fiber Did Not
melt !!!

Discharged!

NP fiber
Did melt
= 10

melt !!!

Prefuse work
fuse \Rightarrow melt

Prefuse wo
fuse mel